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THE ECONOMIC CLIMATOLOGY OF THE COFFEE DISTRICT OF SÃO PAULO, BRAZIL

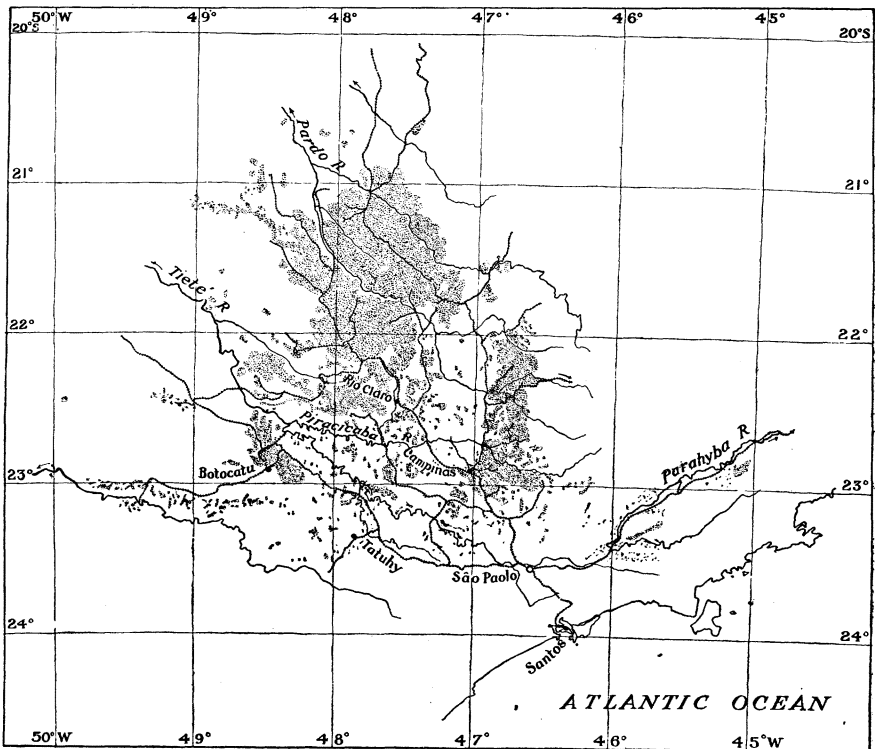
BY

ROBERT DE C. WARD
Harvard University, Cambridge, Mass.

NEED OF "FIELD WORK" IN CLIMATOLOGY: The teacher of climatology, no less than the teacher of geology or of physiography, should travel. He should do "field work." If he is to have a clear understanding of the climates of the world he cannot be satisfied with the published numerical data, no matter how accurate these may be, or how carefully they have been discussed. He will, in addition, want to visit as many parts of the world as possible, in order that he may himself become familiar with the various weather types. In this way, and in no other, can climatic description become really alive, and can the teacher of climatology do his best work for his classes. The natural objection, that it is impossible for one person to make any adequate "field study" of this sort, because of the immense number of different weather types the world over, is a valid one to a certain degree, but it should be remembered that in many latitudes the weather conditions are so uniform, day after day, that a day or two spent there suffices to give a very fair idea of the climate. In the heart of the trade wind belt, at sea, a day's weather and the climate are thus nearly identical. And in many districts, especially within the tropics, where there are two well-marked seasons, a day or two in each of these seasons often suffices to give a reasonably good idea of the character of the whole year.

To the practical climatologist, who concerns himself with applied, rather than with purely theoretical climatology, this "field study" of climate is obviously of peculiar interest in a locality where the climatic conditions are of special importance to man, because of their relation to some particular crop, or to some industry, or to health. There is thus a natural difference in interest in the economic climatology of different regions. For various reasons the writer has lately had his attention drawn to the immense importance of the Brazilian coffee crop. This paper deals with certain climatic aspects of coffee cultivation and of preparation for market which presented themselves during a recent summer trip to Brazil, which was undertaken in order to make first-hand observations of the economic climatology of the Brazilian coffee district.

DISTRIBUTION OF COFFEE OVER THE WORLD: The coffee belt of the world roughly corresponds—conveniently for our memories—with the broad zone within the Tropics, although latitudes 23.5° N. and S. are not to be thought of as rigidly limiting the countries in which coffee grows. The extreme limits of *Coffea Arabica* are generally given as 28° N. and 30° S. Within this great area there are differences of rainfall, both as to amounts and season of occurrence; of temperature; of exposure; of altitude; of soil. It is, therefore,



Map of the Coffee District in the State of São Paulo, Brazil. Scale 1:5,500,000. Stippled areas represent coffee districts. "São Paulo" should read "São Paulo." Based on a map published in 1907 by the Comissão Geográfica e Geológica de São Paulo, scale 1:2,000,000.

impossible to give any rigid climatic limitations for coffee culture, or to draw a map which shall indicate the climates where coffee might be profitably cultivated, valuable as such a map would obviously be to the economic climatologist. Fortunately for man, *Coffea Arabica* is not nearly so exacting in regard to its climatic requirements as are many other tropical plants of economic importance. It does well on lowlands near the equator, and it also does well at altitudes of 2,000 feet near the margins of the tropical belt. By far

the greater part of the world's coffee crop, however, comes, not from the middle of the belt, near the equator, but from the hill-slopes or plateaus some few hundreds of feet above sea-level near the "temperate zones." In other words, coffee succeeds best in the more temperate climates of the tropical zone, in just those climates which are best suited to Europeans and North Americans. To-day, coffee comes chiefly from the New World, and from south of the equator. Temperatures fairly high and uniform (monthly means of 60° or 65° to 75° or 80° Fahr.), and rainfall in reasonable amount (*i. e.*, higher than that of most of the "temperate zones"), say 60 inches and over, are generally found. Excessive humidity is injurious because of its effect upon the diseases of the coffee plant, and upon the growth of weeds, although otherwise a high relative humidity is beneficial.

Naturally, the different species of coffee differ greatly in their relation to climate, some doing better at higher elevations, and others at lower; some withstanding drought better, and others thriving only where there is a more even distribution of rainfall; some being more and others less resistant to cold. The distribution of rainfall is an important factor, a dry season during harvest-time being a very desirable feature, especially where sun-drying is practised. The dry winter season of Brazil is worth millions of dollars to the coffee-planters of that country. In general, climates which are very hot and very damp are somewhat less favorable than those which have a relatively dry season during certain months.

THE BRAZILIAN COFFEE DISTRICT: Among all the coffee-producing countries of the world, Brazil stands pre-eminent. She is the colossus. She alone sends out annually about three-quarters of the world's total coffee crop. No reading of books on coffee can give any adequate idea of the extraordinary position which coffee occupies in the world's commerce. To appreciate this remarkable situation one must travel for hour after hour through the rich coffee plantations of Brazil; must live in their midst, and must make a study of the methods of planting, cultivating, harvesting and preparing the coffee for market, including the wonderfully ingenious machinery which has been invented to deal with this one particular crop. The coffee district of Brazil is situated in the highland or plateau region to the south and west of the city of Rio de Janeiro, chiefly in the state of São Paulo (latitudes 20°-25° S., longitudes 44°-53° W.), although the adjacent states of Minas Geraes, Espirito Santo and Rio de Janeiro are also coffee producers. This "Brazilian Highland," so-called, is the great table-land of central and southern

Brazil, averaging about 2,000 to 3,000 feet above sea-level; sloping gently inland and westward; falling off abruptly to the sea on the east. Open campos and scattering woodlands occupy the greater part of its surface. The eastern portion is mountainous, the most marked feature being the sea-coast mountain ranges of the Serra do Mar and the Serra do Mantiqueira. The western portion belongs to the basin of the Parana River, and is crossed by several small mountain ranges, roughly parallel to the Serra do Mar. The coffee country *par excellence* is a gently-rolling district a little south of the Tropic of Capricorn.

The importance of the Brazilian coffee crop in the world's markets naturally draws attention to the particular small section of that great republic in which the conditions have proved so favorable for the cultivation and preparation of this remarkable plant. Those who have travelled for hours through those oceans of coffee trees need no further assurance that this is the center of the world's coffee crop. Nowhere else in the world does coffee grow more luxuriantly; nowhere else does it find a more congenial climate; nowhere else does it require less care; nowhere else is it more free from enemies. Such a condition of things is unique; it is phenomenal; it irresistibly attracts the traveler. He is drawn to it as he is drawn to visit the world's greatest diamond mine, or steel plant, or ship-yard, or waterfall. It matters little in such a country whether there are (as statistics say) over 15,000 coffee plantations. It matters little whether there are 600,000,000 or 700,000,000 coffee trees. It matters little whether the invested capital is \$500,000,000, or more, or less. It matters little, because figures mean little to most of us, and because the vastness, and the extent, and the importance of the coffee industry are here so obvious without any statistics.

The most natural way for a visitor from the United States to enter the Brazilian coffee country is to land at Rio de Janeiro, and to travel thence by train to the city of São Paulo, a distance of about 300 miles to the southwest. This trip, through the Parahyba Valley, dusty as it is in winter, and monotonous, is nevertheless interesting from the fact that here used to be the centre of coffee culture. The coffee tree was first introduced into the city of Rio de Janeiro about 1750 by a monk, who planted it in the garden of the monastery of San Antonio. Early in the last century the cultivation of coffee became recognized as a profitable occupation, and gradually the hill-sides of the state of Rio de Janeiro, especially in the Parahyba Valley, became covered with coffee trees. The crop was so successful that it helped greatly to give Rio its prestige as a commercial centre,

just as, in recent years, coffee has been the chief impetus behind the extraordinary development of the cities of São Paulo and Santos, and has led to the building of most of the railroads in the state of São Paulo. The traveler between Rio and São Paulo may today see from the train many abandoned coffee plantations, dry and dead, whose owners became wealthy men, but whose manor-houses and outbuildings are falling into ruins. In fact, much of this country today looks forlorn and neglected. Whoever looks at these barren hillsides, especially in winter, is easily tempted to infer that a change of climate has made coffee-culture in this district impossible. Such is not the case. The fact is that coffee has been found to succeed so much better in the state of São Paulo, that it no longer pays to keep up most of these old plantations in the state of Rio de Janeiro. Exhaustion of the soil; the development of new railroads in the country farther south; and other factors have combined to produce the change here noted. Nevertheless, coffee culture has not been entirely abandoned in this district. The traveler may still see thriving plantations here and there from the train. But sugar cane and other crops are taking the lead. In this district the first experience in Brazilian coffee culture was gained. Interesting studies were here made as to the value of longer and shorter exposure to sunshine. A classification into *soalheiro* and *norwega* lands separated the slopes into those which had the longest duration of sunshine (*soalheiro*) and those which had sunshine only in the early morning (*norwegas*). Many local peculiarities of climate were discovered by the early coffee planters of the Parahyba Valley. Certain districts which were protected against cool winds were found to require coffee culture at greater altitudes. In some districts dry northerly winds were found to be injurious, while in others they were welcomed. Van Delden Laërne has called attention to many of these very interesting local climatic controls over coffee culture in this Rio zone, but the day has passed for any further detailed studies along these lines, for the Rio coffee belt is largely no more. Van Delden Laërne, in 1885, divided the coffee country into two zones, (1) the Rio or maritime zone, where the climate is to some extent controlled by the ocean and where coffee must be cultivated at from 250 to 350 meters above sea-level, and (2) the Santos zone, to the west and southwest, separated from the ocean by the Serra do Mar, and open to the southwest winds (*pamperos*) from the Argentine plains. The same writer rejects the division suggested by Couty, into a section where the soil is the chief control and into one where climate is the only measure of success.

The São Paulo coffee district is easily reached in a day's journey by rail from the city of São Paulo, along any one of the several lines of railway which run in a northerly and northwesterly direction from the city. Campinas (alt. 2,165 ft., 84.5 miles from the sea) was formerly the center of the best coffee plantations, but in recent years the rapid extension of the area inland and northward has displaced the center further to the northwest. In the vicinity of Campinas, however, there is still much coffee, and the traveler from São Paulo here sees his first large coffee plantations. From here on it is a journey of wonderful interest to any observing person, in spite of the red dust which in winter is very disagreeable, although the ballasting of some of the railroads with stone has recently greatly improved matters. Coffee trees are everywhere; coffee trees by the hundreds of thousands; coffee trees by the million. Monotonous the view is, if you will. To many it has seemed so. But to anyone who really enters into the spirit of the place the monotony becomes variety. It is inspiring to be at the very heart of this country whose product is so valuable that it has made, and will make fortunes; that its varying prices are quoted in the daily papers all over the civilized world; that a national government has actually gone into the business of "cornering" it.

Many factors are concerned in producing the extraordinarily favorable conditions which have made this small part of Brazil the most important coffee country in the world. Among these are soil, altitude, exposure, absence of many insect pests and diseases. One fundamental control is, however, to be found in the climate. It is because of its relation to coffee culture that the climate of the state of São Paulo has such a live interest for the climatologist, an interest which is not satisfied with any published studies of this climate. Such an interest compels a personal visit to this wonderful coffee country itself in order that the actual weather conditions may be seen and felt; so that their control over the cultivation and preparation of the coffee may be studied on the ground. Such was the object of the writer in making a trip to Brazil in the summer of 1910: to make some observations, at first hand, of the economic climatology of the coffee-district of São Paulo. Through the courtesy of Dr. Plinio Da Silva Prado (Harvard, '95), of São Paulo, he was enabled to visit two well-known and representative Brazilian coffee fazendas, that of Santa Veridiana, belonging to Conselheiro Antonio Prado, with 500,000 trees, and that of Santa Cruz, at Elihu Root, belonging to the Chaves family, with 450,000 trees. The latter was selected as the fazenda to be visited by Secretary (now Senator) Root during his South American trip, and the railroad station was then renamed

in his honor. At both these fazendas the writer was entertained with delightful hospitality, and was given every facility to study each step in the process of cultivating the coffee and of preparing it for market.

THE CLIMATE: Fortunately for the layman, the essential characteristics of the climatology of São Paulo are simple and easily remembered. Fortunately for the climatologist, São Paulo has a very considerable series of excellent meteorological observations, which were begun in 1887 under the direction of Dr. Orville A. Derby, of the *Comissão Geográfica e Geológica de São Paulo*, and constitute the most complete series available for any part of Brazil, or for any portion of tropical South America. To Dr. E. L. Voss we owe a very acceptable study and summary of these data, and it is to Dr. Voss's monograph that everyone must go for the most complete account of São Paulo climate ("Beiträge zur Klimatologie der südlichen Staaten von Brasilien; *Pet. Mitt., Ergänzungsheft* 145, Gotha, 1903), although the excellent summary in Hann's "Handbuch der Klimatologie" 3d ed., Vol. II^a pp. 392, 394, 411-413, will probably suffice for most persons.

Singularly favorable as regards climate is the situation of the famous São Paulo coffee district. And it is clearly this favorable, we may say ideal, situation which has contributed largely towards making the district famous for its coffee. Lying near the margin of the southeast trade belt, it is not too far from the equator to be reached by the equatorial rains in the summer, and a sufficient rainfall is thus assured for the proper growth of the coffee trees. On the other hand, the prevalence of the trades during the winter months brings the dry season which is of such immense economic importance in the harvesting and drying of the crop. Further, being near the outer limits of the "hot belt," and at an altitude of several hundred feet above sea-level, the heat is not so intense as to necessitate any protection against the sun except in the case of the very young trees. On the other hand, the danger from frost, which is certainly present in winter, has been greatly exaggerated by many writers. Frosts do occur, but it is only at intervals of several years (say six or seven) that they rarely do any damage which is worth much consideration. Finally, as regards relative humidity, the conditions are such that the air is dry enough for outdoor drying in winter, and not so damp as to promote the excessive growth of weeds in summer. Such a combination of climatic conditions is indeed an ideal one. There are few districts in the world whose economic climatology is more important. A visit to such a country is of the greatest interest to the climatologist.

The accompanying table (Table A) gives a general idea, so far as printed data can do so, of the temperatures of the São Paulo coffee district. Of the five stations here included, Rio Claro, Campinas and Botucatú are the best representatives. The city of São Paulo itself is not in the coffee country. The three first-named stations agree in having six (or seven) months with mean temperatures over 68° Fahr. For this reason, this famous coffee country comes within Köppen's "subtropical belt of the temperate zone," whose characteristics are that four to eleven months are "hot" (mean temperature over 68°) and one to eight months are "temperate" (50°-68°).^{*} The mean annual temperatures average between 65° and 70°. January is usually the warmest month and June the coolest. The ranges, annual, monthly and diurnal, as a rule increase inland. The mean annual ranges in the coffee country average from 12° to 15°. In summer the thermometer may rise to near, or even above, 100°. The extremes of summer heat are brought by northwesterly winds, from the interior, which are also extremely disagreeable because of their carrying large quantities of fine red dust. We have a story, on excellent authority, which illustrates the intensity of the summer heat in the coffee country. During a spell of intense heat, and drought, when everything was "sizzling hot," a large snake which started to crawl across an iron surface, was seen to die almost instantly.

TABLE A

TEMPERATURES IN THE SÃO PAULO COFFEE DISTRICT (HANN)

STATION	SÃO PAULO	TATUHY	RIO CLARO	CAMPINAS	BOTUCATÚ
S. Lat.....	23°33'	23°27'	22°25'	22°58'	22°50'
W. Long.....	46°38'	47°46'	47°39'	47° 7'	48°25'
Altitude.....	2493 ft.	1968.5 ft.	2000 ft.	2165 ft.	2625 ft.
No. of Years.....	13	12	11	10	5
Dist. from Ocean (miles)	32.3	84.5	128	84.5	134.2
Jan.....	71.1°	73.2°	75.6°	73.2°	72.7°
Feb.....	70.7°	72.3°	74.7°	72.5°	72.1°
Mar.....	70.0°	71.8°	74.3°	72.1°	71.6°
Apr.....	65.7°	66.4°	70.2°	68.0°	66.9°
May.....	61.2°	61.9°	64.9°	63.3°	61.9°
June.....	57.9°	58.3°	61.5°	60.4°	58.5°
July.....	57.6°	58.7°	61.9°	60.6°	60.1°
Aug.....	60.1°	61.7°	65.7°	64.2°	63.7°
Sept.....	61.9°	63.0°	67.6°	65.3°	65.1°
Oct.....	64.6°	67.1°	71.1°	68.2°	68.9°
Nov.....	66.7°	69.8°	72.7°	70.0°	71.1°
Dec.....	70.0°	73.0°	74.8°	72.7°	73.8°
Mean Annual.....	64.8°	66.4°	69.6°	67.6°	67.3°
Mean Annual Range..	13.5°	15.0°	14.0°	12.8°	15.3°
Absolute Maximum...	91.6°	(108.5°)	(97.3°)	(98.1°)	(100.0°)
Absolute Minimum....	35.2°	(28.8°)	(28.8°)	(31.6°)	(32.0°)

N. B. The maximum and minimum given for São Paulo are mean annual maximum and minimum.

^{*} See R. DeC. Ward: "Climate." pp. 28-29.

Obviously, the summer months, with their high temperatures and heavy rains, are not the best season for visiting the coffee district. We must go there in winter if we would enjoy the climate at its best. A glance at the table shows that the winter months have mean temperatures of, roughly, between 60° and 65° , and that the minima have fallen to freezing, and somewhat below. But what does that really tell us about the winter weather types—those wonderful days, of which the writer has seen many, on the campos of southern São Paulo and of Paraná in 1908 and in the coffee district in 1910, with their cool, crisp, sparkling air of early morning; their warm noon hours, their refreshing evenings, and their gloriously clear skies? No wonder is it that Europeans have settled so largely in the southern states of Brazil, for the climate is a “white man’s climate.” During his stay at the coffee fazendas in August, 1910, the writer found the temperatures of the early mornings (about 7 A. M.) between about 50° and 60° , or a few degrees over 60° ; in the warmest hours of the day it was between 80° and 82° ; and in the early evening (6-7 P. M.) about 75° . These are ideal conditions for health and pleasure in the dry air of the winter months.* Add to such temperatures a sky which is prevailingly cloudless or has only scattering clouds; and a light wind, and you have a combination of elements which should satisfy all but the most exacting seeker after a congenial climate.

The writer obtained temperatures of 55° - 60° in the city of São Paulo in August, 1910, in the morning and evening, and 70° - 75° in the early afternoon. The weather was clear or cloudless all the time, and the wind light S. E. The prevailing direction of the winds (the southeast trades) is very generally indicated by the unsymmetrical growth of many trees which often serve, here as elsewhere, as excellent wind vanes. Local topography frequently deflects the trades into other directions than southeast, over limited areas, as the writer has had occasion to observe. The general southeasterly winds weaken in summer, under the high sun, following the usual law in these latitudes, and are replaced by hot winds from the northwest. The latter are especially marked in the interior, where they are so distinct that Voss has called them the northwest monsoon. It is these summer winds, or calms, which bring the rains. Following the wind changes, the relative humidity is usually higher in summer and lower in winter, although near the ocean, where the trades are both cooler and damper than in the interior, the humidity is high through the year, and showers are not uncommon even in winter. It is asserted

* In the writer’s note book, Aug. 13, 1910, there is this entry: “For a teacher of climatology a journey of 10,000 miles for one such day is well worth while.”

by Voss that rivers, swamps and forests locally increase the humidity, but that the coffee plantations have no such effect. Cloudiness is at a maximum in January and February in the interior, and at a minimum in July and August, following the seasonal changes in general weather conditions.

The rainfall over the coffee district averages between about 45 and 60 inches. The rainfall of the coast is generally a good deal heavier than that of the interior on account of the free exposure of the former, with its mountain ranges, to the easterly trade winds. Santos, on the coast, at sea-level, has about 90 inches, while the annual mean at Alto da Serra (2,625 feet), the highest point on the line between Santos and São Paulo (city), is 145.55 inches. São Paulo itself has just over 50 inches. The coffee district is therefore plentifully watered, a fact which not only greatly facilitates the harvesting and preparation of the coffee, but also provides a certain amount of river transportation. The general conditions of rainfall for this region are illustrated in the data given in Table B for three representative stations. This distribution of rainfall furnishes a good illustration of the so-called "tropical type," which is found at the margins of the trades, where the equatorial rain belt encroaches, in the summer months, upon the trade wind area. January is usually the rainiest and July the driest month, but even the so-called "dry season" has some precipitation. The rain probability is also greatest and least in these same months. By seasons the probability of rain at Rio Claro and at Campinas is as follows:

	SUMMER	AUTUMN	WINTER	SPRING
Rio Claro.....	51	25	13	32
Campinas.....	57	28	16	35

In the interior, the hours from 2 to 4 P. M. are on the whole the rainiest. Heavy thunderstorms, not infrequently accompanied by hail, occur in summer. The hail may seriously injure the coffee trees, even, as some authors have said, "almost totally destroying whole plantations." The present writer was, however, unable to discover that damage by hail is really much feared by the fazendeiros,

TABLE B

MONTHLY RAINFALLS IN THE COFFEE DISTRICT (Voss)
(in inches, to nearest hundredth)

STATION	YEARS	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY
Campinas..	10	7.13	10.87	8.74	7.48	2.79	2.72	2.16	0.71
Rio Claro..	11	7.01	9.21	8.07	5.47	2.60	2.24	1.97	0.43
Botucatú..	3	3.42	9.25	7.60	7.36	1.73	1.77	2.01	0.59
		AUG.	SEPT.	OCT.	NOV.	YEAR			
Campinas..		1.34	3.23	5.59	6.46	59.72			
Rio Claro..		1.18	3.46	4.68	7.01	53.78			
Botucatú..		0.47	1.77	5.00	5.00	46.30			

and he could find no case of hail insurance. As the *administrador* of one coffee fazenda said, "the hail falls in such narrow belts that I am not afraid of its doing much damage." And that seems to be the general opinion. That the hail-storms of the campos of *southern* Brazil may be very severe the writer had occasion to observe in 1908 when crossing the state of Paraná, and it may well be that even in the coffee district men and animals are sometimes injured, as reported by some writers. One economic aspect of heavy rainfalls in this country is their effect in washing the roads, which are none of the best even in the dry season, and making travel, even in the famous Brazilian "trolley" (a kind of rude buckboard) difficult. Nocturnal radiation fogs are very common, especially in winter, in the valleys and on the lower slopes of the hills. No traveler who is obliged to be up early in order to take the morning trains, which very commonly start at about 6 A. M., can fail to note the frequent occurrence of these fogs. Fogs, and heavy dews, are doubtless a very effective aid in providing moisture for vegetation at a time when such moisture is most needed. The writer, during his recent trip, made special note of the occurrence of fogs and of very heavy dews. The former doubtless often serve as a protection against frost, while the latter may be injurious to coffee which is spread out on the drying-grounds, unless coverings are used at night.

SOIL: It must not be supposed that no emphasis is to be laid upon the soil of the São Paulo coffee district in helping to produce the wonderfully favorable conditions of that region. In the older, or eastern coffee belt of Rio de Janeiro and of eastern São Paulo the soil is decomposed granite and gneiss of Archaean age. But the interior of São Paulo is composed chiefly of sandstones and shales of Devonian and Carboniferous age, traversed by numerous dikes and intrusive masses of diorite and other eruptives. It is the decomposition of the latter which produces the rich red soil that has become famous as the *terra rossa* and is regarded as the best for coffee culture, being wonderfully fertile, very rich in potash, and containing much iron. The *terra rossa* lands are the most valuable and most keenly desired by coffee planters. They are adapted for the growth of coffee as no other soils seem to be, and the term has become almost synonymous with "a soil suitable for coffee planting." For various modifications of this soil the terms *terra vermelha* and *terra massapé* are used. The sandstones yield *terra areia* (sandy soil) which is further classified as *preta* (black), or *branca* (grey), etc. But the red soil is by far the best, and is justly famous where-

ever coffee cultivation is discussed. The traveler very soon learns to predict his approach to a coffee plantation simply by noting the occurrence of red soil, seen from the window of the train.

SOME CONTROLS OF CLIMATE OVER COFFEE CULTIVATION: We have, then, in the state of São Paulo, a rare combination of elements singularly favorable to coffee culture. Favorable as these conditions have shown themselves to be, man has, nevertheless, been obliged to adapt his methods of cultivation and his methods of preparation to the climate in a number of rather striking ways. The climatic control is to be seen throughout, if one is only on the watch for it. Exactly such facts as these are what the economic climatologist is interested in: it is in order to see them that he is anxious to do "field-work," instead of remaining at his desk at home. Thus, at the very beginning of the plantation, when the virgin forest which still covers the hillsides of the future coffee fazenda is first attacked, the trees are cut down at the end of the rains, and are allowed to dry during the winter months. Towards the close of the dry season, when trees and shrubs are in their best condition for burning, the fires are set, and the whole mass of tangled vegetation is wiped out, excepting perhaps a few tall, dead trunks, which stand for years, silent witnesses to the departed glory of the forest and to its replacement by a growth of trees from which man derives greater economic advantage. This burning, it may be noted, is begun by preference after the night's dew has evaporated. During the dry season there are many field and forest fires in progress throughout this great interior campo country of Brazil, but fire is not feared among the coffee trees, because they are separated from one another and because the roads through the plantation make the control of fire an easy thing. Towards the latter part of the winter, when vegetation is thoroughly dried up, the smoke from burning grass and brush often becomes so thick that the sky is yellow and the sun is partly obscured. The coffee seeds are planted, and the young trees are started in wicker baskets kept under the shade of the forest trees, which are almost always to be found in some part of every fazenda, in order to protect the youthful plants from the sun. In eight to twelve months after planting, the young seedlings are removed from the nurseries to the plantations, where they are placed at distances of 4-5 meters apart. The transplanting should be done at the beginning of the rainy season, and preferably in damp and cloudy weather. The seedlings are set into circular holes dug into the ground, and over the tops of these holes, above the little trees, is laid a loose thatch-

work of corn stalks, straw, twigs or leaves, to serve as a protection against excessive heat, and against frost, but the former seems to be the principal danger in mind. Except in their earliest stages, the coffee trees in São Paulo are not shaded for protection against the sun. In many of the other coffee countries, shade is necessary, and banana trees are very commonly used to provide this protection. In fact, the whole matter of the best shade trees to be used under different conditions has been carefully studied. Such trees as close up their leaves at night, thus offering less obstruction to radiation from the leaves of the coffee itself and resulting in a heavier dew deposit upon the latter, are mentioned by one authority on coffee as being the most desirable. This is surely an interesting example of botany applied to economic climatology. It is apparent that when cultivated near the equator, where insolation is more intense, shade is necessary, whereas towards the margins of the tropical zone, as in São Paulo, such protection is not needed. In its natural state, coffee does best under shade.

Frost is the climatic element which the São Paulo coffee planters fear most, and yet many of the accounts which have been printed exaggerate very much the danger which may result therefrom. The writer was unable to find any considerable fear of frost in the minds of the superintendents of the coffee fazendas with whom he talked. They realize that frost is likely to occur any year; that there have been occasions when large numbers of trees have been damaged, temporarily or permanently; but that no appreciable injury comes oftener than about once in five or six years. They rely on the protection which they give the young plants against sunshine to protect them equally well from frost, and they are very careful indeed to plant their coffee at altitudes which will bring the trees above the frost limits. "Smudges" are not used, so far as the writer was able to ascertain. The smaller danger from frost on the hillsides than in the valley bottoms and on the lowlands has taught the *fazendeiros* to begin to plant coffee at about 600 meters, more or less, above sea-level. The exact altitude varies locally, according to the topography. Each *fazendeiro* knows the usual "frost holes" on his own fazenda, and recognizes the well-known "streakiness" or "patchiness" of frost, which sometimes plays curious pranks in the damage it does. There is no more striking feature of the climatology of the Brazilian coffee district than this marked dependence of the altitude at which the trees are planted upon frost occurrence. Over and over again even the casual traveler cannot fail to be impressed with the fact, plainly visible from the car windows, that the rows of coffee trees do not

extend all the way to the bottom of most of the slopes, but stop short at a certain definite height, corn or some other crop occupying the lowest slopes and the valley bottoms.

The writer, on his recent trip, saw some coffee trees on the *lower* slopes of the hills frost bitten. It has been noted by previous writers that coffee trees may be planted at lower levels where there is a stream flowing through the valley, because under such conditions the relative humidity is higher, and fog, which serves as a protection against frost, is more likely to occur than where there is no river. In many coffee districts where the trees are liable to injury by high winds, or by winds which bring excessive heat or cold, protected situations are sought for the plantations and wind-breaks are planted, but in Brazil this precaution does not seem to be necessary. It is customary, in countries where strong prevailing winds are to be guarded against, to form a judgment as to the exposure of any given locality where coffee-planting is to be undertaken by noting whether the trees of the natural forest are wind-blown. If these show unsymmetrical growth, it is clear that the coffee trees will also suffer. The importance of an abundance of running water in preparing the coffee for market is one of the most striking lessons which the visitor to a coffee fazenda will learn. Hence a sufficiently abundant rainfall is an element of the climate which is essential. There is still another respect in which the São Paulo coffee district is singularly favored, climatically. To one who reads the extensive literature of coffee, it is a most striking fact that Brazil has suffered so little, as compared with most of the other coffee countries, from coffee pests and diseases. This is partly, we may even say largely, the result of the exceptionally favorable climate. Certain of the coffee leaf diseases are pretty surely brought on by a weak condition of the shrubs resulting from prolonged exposure to drought. Other diseases, such as "rot," are due to excessive moisture and low temperatures. Finally, the climate of São Paulo, being neither very hot nor very damp, is far less favorable to the growth of noxious weeds than is the case in many other coffee countries.

THE HARVEST: The harvest in Brazil begins in May and lasts until August or September. It therefore comes in the dry season. The harvest was nearly over during the writer's visit in the middle of August, 1910. The climatic conditions which provide this dry season for the harvest, and for drying the berries, are of peculiar and very marked economic importance. The size of the crop may vary greatly from year to year, depending chiefly upon preceding weather conditions.

Coffee as we know it in the grocery store is the seed of the coffee berry, which is red when ripe, and has about the size and appearance of a small cherry, or a cranberry. The berry normally contains two seeds, flat on one side, convex on the other, the flat sides being together. These seeds are imbedded in a mucilaginous, saccharine, whitish pulp, which has an insipid, sweetish taste, and are themselves further enclosed in two envelopes. The inner of these, when dry, is a delicate, closely adherent, very thin covering, much like the thin skin which covers the white onion, and is known as the "silver-skin." It is easily removed by friction when dry. Outside of this inner covering comes a somewhat tougher, thicker and more loosely fitting envelope, not unlike the husk of wheat. The preparation of coffee for market involves the removal, from the inner seeds or beans, of the outside skin, the pulp and the two inner coverings. These intervening stages involve much care and good judgment, as well as the use of complicated and expensive machinery. The processes consist in: (1) the removal of the outside skin and of the pulp by maceration in water; (2) the washing and drying of the beans, after the removal of the pulp, but with the two inner coverings still on the beans; (3) the removal, when dry, of these two inner coverings, and (4) the sorting of the beans according to size and weight. Among these different processes the one which has the most interest for the climatologist is the drying stage. After the outer skin and pulp have been removed, and the beans have been washed and allowed to ferment a little, they are taken to the drying-grounds (*terreiros*).

DRYING THE COFFEE: The process of drying the coffee beans is the stage in which the greatest skill and care and good judgment are necessary, for upon what happens then, far more than upon the coffee as picked, depends the quality, the color and the commercial value of the coffee beans. During this stage the *administrador* is constantly called upon to decide how long this or that particular lot of coffee should be dried, and at exactly what moment it should be removed to the warehouse, awaiting its turn in going to the hullers. It is the drying stage, also, which has the most interest for the climatologist, for it is controlled at every point by meteorological conditions.

The drying-grounds are rectangular areas, square or oblong, varying a good deal in size, and numbering up to 16 or more on each fazenda. They are paved with Portland cement, square bricks or tiles, and usually have a gentle slope downhill, so that the water which carries the coffee may run off at the lower side, through iron

gratings, into small brick or cement-lined canals. Asphalt floors cannot be used, on account of their softening under the hot sun, and also because they give a taste to the coffee. Upon the separate divisions of these *terreiros* in the drying-season, one may see coffee in many stages of drying and of preparation. There is the coffee which, having been through the pulpers, has had most of the pulp and outer coverings removed, and is being dried before going to the hullers. There is coffee which went through the pulpers but which was not properly pulped, being too green, or too dry, or too small; this also is being dried, in order that outer covering and dried pulp and inner coverings may all be removed in the next stage. There is coffee which was too dry and too tough to go through the pulpers at all. There is coffee in all stages of drying. Each one of ten or a dozen separate divisions of the *terreiros* may contain a lot of coffee in a different stage of drying, and requiring different periods of drying. All this the *administrador*, or one of his immediate subordinates, has to look after, and it is just here that there is the greatest need of good judgment and of experience. When the *terreiros* are well filled, during harvest-time, they present an interesting scene, with many laborers constantly moving about, spreading out the coffee or gathering it up into heaps so that fermentation may take place; giving some more sun and some less sun; always under the watchful eye of the superintendent whose decision in each case is final. There can be no hard and fast rule about drying coffee; it is almost true that each wagon-load of coffee from the harvest requires separate treatment. In order to increase the temperature on the *terreiros*, the tiles are blackened, and under the noon sun and the cloudless skies which are characteristic of winter, the absorption of insolation is very great, and the heat, as one walks across the drying-grounds, is very intense. It was a constant source of wonder to the writer that the Italian laborers occupied in the drying of the coffee were able to walk with bare feet over these *terreiros*. The heat, and dryness, and glare were desert-like in their quality. The weather was simply ideal for drying: hot early afternoon hours, cool evenings and nights; low relative humidity; light wind, sufficient to promote active evaporation, yet not enough to blow the coffee about. No one can fully appreciate what outdoor drying means who has not been to the coffee country, and who has not himself experienced the weather conditions which prevail during the winter. During the writer's stay at the *fazendas* of Santa Veridiana and Santa Cruz the days were almost cloudless, with a light wind whose direction was evidently controlled by the topography, but which was in general easterly. The

early afternoon temperatures rose to 80° or a little over, with relative humidity between 45% and 50%. In the evening and early morning the thermometer read down to between 50° and 70°, with relative humidities of 70%-75%. On the *terreiros* themselves, in the early afternoon, the temperatures ranged from 2° to 5° higher than those above noted, and the relative humidities were between 40% and 45%. There was a striking absence of cumulus clouds, and it was noticeable that there was but a little inconvenience from perspiration. Both of these features are explained by the dryness of the air. The *administrador* of the Santa Veridiana *fazenda* told the writer, at the time of his visit in August, 1910, that the weather was wonderful for drying, and that no one could ask for anything better.

The duration of the drying-stage naturally varies very greatly: sometimes it lasts only a day or so; sometimes it takes several days, or even weeks. It all depends on the weather, and on the condition of the coffee, whether pulped or not, and whether already more or less dry as it comes in from the trees. Coffee in berry, *i. e.*, not pulped, takes much longer to dry. Rain, while not injurious to coffee on the *terreiros* which is still wet, is a serious injury to beans which are already nearly, or quite dry. Hence it is customary to have the coffee piled up at night at the center of each division of the *terreiro*, and covered over with canvas,* held down at the corners and edges with bricks. In São Paulo there is not much danger of any considerable damage from heavy rains in the winter months and the canvas coverings are usually quite sufficient protection.† Care is also needed to keep coffee which is in a critical stage of drying from excessive baking under the hot sun. It is an important part of the duty of the night watchman on a Brazilian coffee *fazenda* to keep watch of the weather, and in case of threatening rain, or of a high wind which might blow the coffee away, to summon the "colonists" to gather and cover up the beans.

The usual method of determining whether the coffee has been sufficiently dried to go to the hulling machines is to rub some of the beans hard between the palms of the two hands. If the two inner envelopes are removed by this friction, and are dry and brittle instead of tough, it is a sign that the beans are ready to be removed from the *terreiros*. Absolute dependence upon weather conditions, as happens in the open-air drying method, is often a long and always a more or less uncertain process. Therefore, just as we see, around

* Sometimes mats, or zinc covers, or bunches of long grass are used instead.

† In countries where heavy rains are expected, the coffee is sometimes kept out in trays or drawers, which are easily carried under cover or covered over. Other devices, such as metal roofs on wheels, which can be rolled out to the *terreiros*, are also sometimes used.

our large cities, more and more cultivation of garden truck under glass, where artificial heating, and watering, and protection against hail and heavy rains and frost, are easily provided, so the artificial drying of coffee seems likely to solve the difficulties of sun-drying. Artificial drying is the result of man's ingenuity in making himself more and more independent of the uncertainties of the weather. There are already several appliances for steam-drying coffee on the market, and it is likely that in time these will come into more and more general use, to supplement perhaps, rather than to replace, the open-air drying. At present, however, there is a strong feeling on the part of most of the *fazendeiros* that sun-drying gives better results: that the coffee dries more uniformly and has a better color and flavor.

With the further stages in the process of preparing coffee for market we are not here concerned, because the climatic control plays no further part in them. From the plantations, when ready for market, the coffee is shipped in bags weighing 60 kilograms each (132 lbs.) to Santos, where it is put into warehouses and then loaded on board steamers bound to all parts of the world.

HUDSON LAND

BY

EDWIN SWIFT BALCH

During the return voyage of the *Terra Nova* from McMurdo Sound, South Victoria Land, in February and March, 1911, an important geographical discovery was made which clears up one of the lacunas in our knowledge of the Antarctic Regions, namely, the position of the coast line of East Antarctica between the northwest extremity of Victoria Land and the eastern point of Wilkes Land.

This discovery by the British Antarctic expedition is announced in the *Geographical Journal*, for May, 1911, p. 569, in the following words:

"The ship afterwards cruised in the vicinity of the Balleny Islands, and, though much hampered by strong winds and foggy weather, discovered (February 22) a mountainous land in about 69° 50' S., 163° 20' E. It was seen again on February 25, and followed to 68° 30' S., 158° 15' E., but the heavy pack (in which the ship was caught for a time) did not permit an approach within 10 miles. The pack was finally cleared on March 8."